Middle Cerebral Artery Doppler Indices in Preeclampsia for Prediction Fetal Outcome

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Abstract: Hypertension disease is a major cause of maternal mortality; it's also responsible for perinatal morbidity and mortality mainly due to its effect on the growing fetus. Preeclampsia (PE) which is characterized by high blood pressure, proteinuria and edema is threatens the maternal and fetus life. Doppler Ultrasound (US) study has been considered as primary tool of choice for PE patients' assessment. To assess Doppler studies of fetal middle cerebral artery (MCA) indices in PE patients for prediction of PE and adverse perinatal outcome. A prospective study on 221 pregnant women (100 with preeclampsia and 121 with normal pregnancy) of fetal MCA indices was performed using Doppler US then perinatal outcomes were monitored. The data was presented in percentage and discussed, between patients age, gestational age (GA), parity, diastolic, systolic, pulsatility index (PI), resistant index (RI), and systolic/diastolic ratio (S/D ratio) of fetal MCA Doppler indices and its correlated to fetal outcome, were analyzed statistically. Then the results were discussed. Doppler study in PE patients is a non-invasive hemodynamic study; abnormal waveforms are associated with the adverse perinatal outcome in our study. It is useful guide to plan timely intervention so as to reduce perinatal mortality and morbidity.
Keywords: Doppler, Preeclampsia, MCA, S/D ratio, PI, RI.

INTRODUCTION

Hypertension disorder in pregnancy is a major cause of maternal mortality, which is also responsible for perinatal morbidity and mortality mainly due to its effect on the growing fetus [1].

The incidence of all hypertensive disorders in pregnancy may be as high as17% in nulliparous women, with the incidence of preeclampsia reportedly between 2 and 7%[2].

Hypertension during pregnancy is classified as preeclampsia if accompanied by proteinuria, or gestational hypertension, when is not accompanied by proteinuria. About 40% of cases of gestational hypertension will develop proteinuria and be classified as preeclamptic, the remaining 60% do not develop proteinuria, and after pregnancy are classified as having transient hypertension of pregnancy. These different forms of hypertension during pregnancy have very different risks for mother and baby. The most serious is preeclampsia, a syndrome present in 3 to 5% of pregnancies [3].

When preeclampsia occurs in a woman with chronic hypertension, which happens in about 20% of cases, this is termed superimposed preeclampsia. It is the major factor leading to maternal and infant mortality and morbidity in these women. Gestational hypertension, which does not progress to preeclampsia, presents minimal risk to mother or baby[4].

Pre-eclampsia has been shown to be associated with an increased middle cerebral artery blood flow velocity (MCAFV) and abnormal transcranial Doppler (TCD) findings compared with the healthy pregnant state [5].

It has been well established that the use of Doppler velocimetry can significantly reduce perinatal death and unnecessary induction of labor in the preterm and intrauterine growth retardation (IUGR) fetus [6].

Although the etiology of pre-eclampsia remains unclear, current thought is that it follows from the failure of second-wave trophoblastic invasion in the late first and early second trimesters [7].

The aim of this study is to assess the middle cerebral arteries using Doppler US parameters [RI, PI,

S/D ratio] in pregnant women, in order to make an evaluation of hemodynamic repercussion caused by the established PE.

Objective

To assess the fetal middle cerebral artery indices (PI, RI and S/D ratio) in Preeclampsia patients using Doppler ultrasound for predicting fetal outcomes.

MATERIALS AND METHODS

This a descriptive cross sectional study, was conducted in Sudan at Omdurman maternity hospital feto-maternal unit, after obtaining hospital ethics committee approval, in time span of two years.

Two hundred and twenty one pregnant women subjected to routine ultrasound followed by color Doppler, equipped with Toshiba Power Vision 6000, with 3.5 MHz convex transducer, flow measurements of fetal MCA indies were taken in a transverse plane slightly closer to base of skull, at the level of the greater wings of the sphenoid bone, the sample volume was placed after the origin of MCA. An angle of zero degree is used typically. One exam on each patient was carried out include one middle cerebral artery; recordings were made in the absence of fetal body or breathing movements. All the measurements were performed with the patients in supine position and did not talk or move during the examination.

Patient characteristics that were recorded include maternal age, parity, gestational age, blood pressure and MCA Doppler measurements, and then fetal outcome monitored and statistically analyzed.

All patients had aged between 17 to 42 years old, with singleton pregnancy and had GA between 26–40 weeks which was documented by confirmed last menstrual period (LMP) and/or first-trimester ultrasound dating. The cases group consisted by diagnosed PE women, which was defined as an arterial pressure greater than 140/90 mm Hg, with associated proteinuria (>1+ on dipstick and/ or >0.3 g litre on a 24-h collection), occurring after the 20th week of gestation.

Pregnant women with multiple pregnancies, having history of chronic hypertension, gestational diabetes, cardiac disease, and middle cerebral artery pathology were excluded. Neilson J P *et al.* mentioned that Doppler ultrasonography has given an improved access to fetal circulation [8].

A previously reported mentioned that error for MCA measurements are less than 10% [9-11]. The data have been analyzed by a Statistical Package for Social Sciences (SPSS) by using various statistic methods, for tested the normality of distribution by visual comparison, comparing each distribution with the normal distribution.

Values are given as percentage or mean+/- SD or median (range). Decreases of RI, PI or S/D ratio values, in the middle cerebral artery were considered as an abnormal artery result.

THE RESULTS
Descriptive study of cases group

Table-1: frequency distribution of age group:

Age/years	Frequency	Percent	Valid Percent	Cumulative Percent
17-25	30	30.0	30.0	30.0
26-33	51	51.0	51.0	81.0
34-41	18	18.0	18.0	99.0
more than 41	1	1.0	1.0	100.0
Total	100	100.0	100.0	

Table-2: shows frequency distribution of parity

Parity	Frequency	Percent	Valid Percent	Cumulative Percent
PG	33	33.0	33.0	100.0
1	14	14.0	14.0	14.0
2	14	14.0	14.0	28.0
3	14	14.0	14.0	42.0
Multiparous	25	25.0	25.0	67.0
Total	100	100.0	100.0	

Table-3: frequency distribution of family history of preeclampsia

Family history	Frequency	Percent	Valid Percent	Cumulative Percent
No	46	46.0	46.0	46.0
Yes	54	54.0	54.0	100.0
Total	100	100.0	100.0	

Table-4: Shows min., max., and mean and std. deviation for age, GA, systole, diastole, PI, RI and S/D ratio

Characteristic	N	Minimum	Maximum	Mean	Std. Deviation
Age	100	17	44	28.77	5.864
GA	100	22	41	33.57	4.354
Systolic	100	140	200	151.48	12.001
Diastolic	100	89	120	99.12	8.672
PI	100	.80	2.99	1.6109	.48656
RI	100	.40	1.08	.6943	.14194
S\D ratio	100	1.40	5.50	3.2347	.88371
Valid N (listwise)	100				

Table-5: Severity of preeclampsia

Severity	Frequency	Percent	Valid Percent	Cumulative Percent
Mild	55	55.0	55.0	55.0
Severe	45	45.0	45.0	100.0
Total	100	100.0	100.0	

Table-6: frequency distribution of outcome in cases group

Outcome		Frequency	Percent	Valid Percent	Cumulative Percent
IUGR	No	42	47.7	47.7	47.7
	Yes	46	52.3	52.3	100.0
Preterm	No	59	67.0	67.0	67.0
	Yes	29	33.0	33.0	100.0
IUDF	No	74	84.1	84.1	84.1
	Yes	14	15.9	15.9	100.0
Delivery Mode	C/S	59	67.0	67.0	67.0
	Normal	29	33.0	33.0	100.0
Eclampsia	No	70	79.5	79.5	79.5
	Yes	18	20.5	20.5	100.0
Total		88	100.0	100.0	

Table-7: Compare means Doppler indices and outcome in cases group

Outcome			S/D	RI	PI
IUGR	Yes	Mean	3.1148	.6639	1.6859
		Std. deviation	.72385	.13923	.50337
	No	Mean	3.4407	.7245	1.5226
		Std. Deviation	.99725	.13533	.47500
IUFD	Yes	Mean	2.7664	.6143	1.3914
		Std. deviation	.80028	.09517	.40897
No		Mean	3.3657	.7077	1.6489
		Std. Deviation	.86112	.14255	.50046
Preterm	Yes	Mean	3.1655	.6403	1.5783
		Std. deviation	.96394	.11930	.45607
No		Mean	3.3219	.7186	1.6225
		Std. Deviation	.83246	.14300	.51488
C/S		Mean	3.2215	.6910	1.6731
		Std. deviation	.86005	.14698	.51855
Normal delivery		Mean	3.3697	.6966	1.4755
		Std. Deviation	.91333	.12681	.41763
Mild PE		Mean	3.4640	.7283	1.5910
		Std. deviation	.95547	.12785	.47130
Sever PE		Mean	3.0380	.6502	1.6282
		Std. deviation	.71288	.14345	.52546
Eclampsia	Yes	Mean	3.3756	.6922	1.5444
		Std. deviation	.76193	.17705	.48197
No		Mean	3.2433	.6930	1.6243
		Std. Deviation	.90543	.13027	.49924

Descriptive study of controls group

Table-8: Shows min, max, std. deviation for age, GA, systole, diastole, PI, RI, S\D ratio for control group cases

Characteristic	N	Minimum	Maximum	Mean	Std. Deviation
Age	121	18	41	27.99	5.158
GA	121	21	41	33.14	4.848
Systolic	121	100	130	113.72	6.847
Diastolic	121	60	88	74.61	6.423
PI	121	1.00	2.90	1.7048	.41736
RI	121	.56	1.20	.8156	.09172
S\D ratio	120	2.20	5.00	3.7533	.83525

Table-9: parity for control group

Parity	Frequency	Percent	Valid Percent	Cumulative Percent
PG	29	24.0	24.0	100.0
1	15	12.4	12.4	12.4
2	32	26.4	26.4	38.8
3	15	12.4	12.4	51.2
Multiparous	30	24.8	24.8	76.0
Total	121	100.0	100.0	

Table-10: family history of preeclampsia

Family history	Frequency	Percent	Valid Percent	Cumulative Percent
Not mention	1	.8	.8	.8
No	113	93.4	93.4	94.2
Yes	7	5.8	5.8	100.0
Total	121	100.0	100.0	

Table-11: frequency distribution of outcome in control group

Outcome	Frequency	Percent	Valid Percent	Cumulative Percent
IUGR	2	2.5	2.5	2.5
C\S	9	11.1	11.1	13.6
Both of them	3	3.7	3.7	17.3
Normal	67	82.7	82.7	100
Total	81	100.0	100.0	Total

Table-12: Compare means Doppler indices and outcome in control group

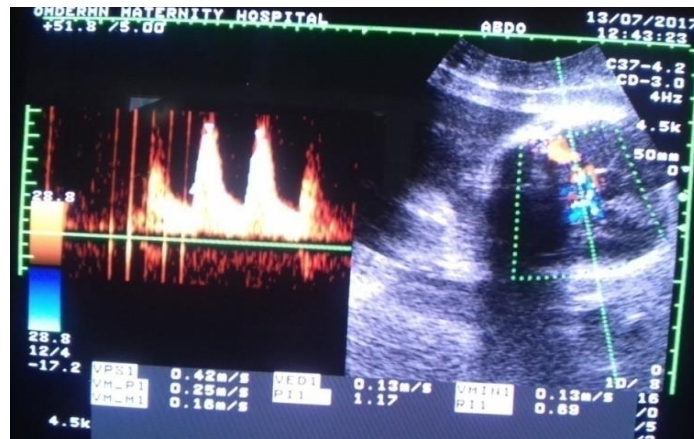| Outcome		PI	RI	S\D ratio
IUGR	Mean	1.8000	.7900	4.6500
	N	2	2	2
	Std. Deviation	.98995	.01414	.49497
C\S	Mean	1.6578	.8067	3.7222
	N	9	9	9
	Std. Deviation	.45293	.01803	.99596
Normal	Mean	1.7658	.8010	3.7303
	N	67	67	66
	Std. Deviation	.40971	.08972	.87442
Total	Mean	1.7500	.8027	3.7625
	N	81	81	80
	Std. Deviation	.41589	.08204	.88022

Fig-1: MCA Doppler ultrasonography of 29 year olds, para2, 31 weeks PE patient with 1.17 PI, 0.62 RI and 3.2 S/D ratio
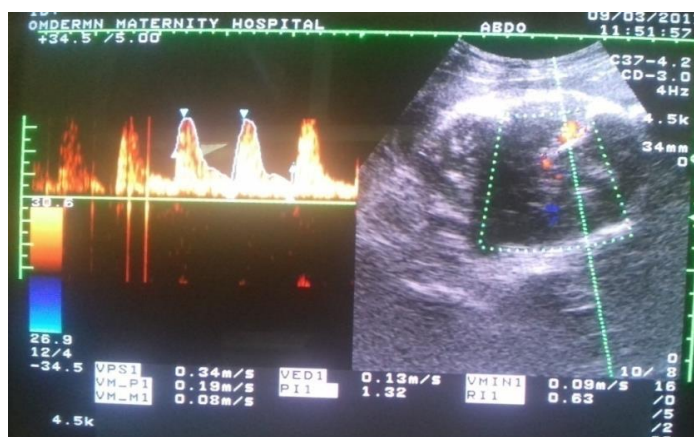

Fig-2: 31 years, PG, 32 weeks PE patient with1.32PI,0.63 RI and 2.9S/D- developed IUGR
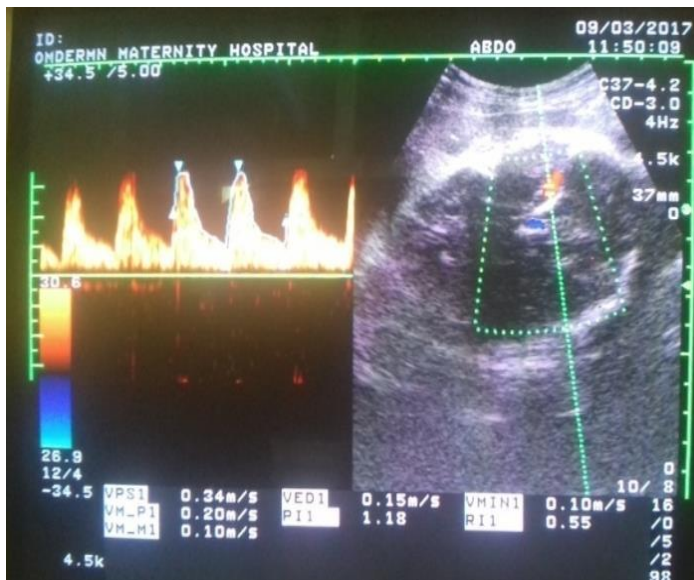

Fig-3: 30 years, PG, 32 weeks PE with 1.18 PI,0.55RI and 2.00S/D ratio-developed IUGR and delivered by C/S

DISCUSSION

This study suggests that MCA indices are predictive of the development of adverse perinatal outcome in pre-eclampsia patients, this supports our previous study which showing a reduced MCA-RI is a sensitive method for assessing IUGR.

In the present study 221 cases sub-divided in two groups: 100 cases group and 121 controls group. Mean maternal age was 28.77+/- 5.86 for the cases (table4), and 27.99+/-5.15 for the controls (table8), so it shows no differences between study groups .This show difference with Lopez-Mendez et al.[12] whom reported

that maternal age was PE risk factor with differences among groups which they study, this differentiation may be due to their small sample volume.

51.0% of cases group were between 26-33years (table1), Padmini C. P. *et al* [13] reported that PE is a disease of young. Out of 100 cases group (33.3%) were primigravida (table 2) where in controls group out of 121 patients 24% were PG (table9), 54% of cases have had family history of PE (table 3), where in controls group were 5.8% (table 10), these results supports the facts that nulliparity and family history of PE have been supported as PE risk factors in several studies [14, 15].

The median of gestational weeks (GW) was 33.57+/- 4.35 for the cases (ranging from 22 to 41 GW) (table4). And 33.14+/-4.48 (ranging from 21 to 41 GW) for controls (table 8), so it shows no differences between study groups.

The mean of diastolic was 99.12+/-8.67 (ranging 90-120) and the mean of systolic was 151.48+/-12.001 (ranging from 140- 200) for cases group (table4), 74.61+/-6.423 (ranging 60- 88) and 113.72+/-6.84 (ranging 100-130) respectively for controls group (table 8).

The mean of PI was 1.6+/-0.48 (ranging from 0.80 to 2.99) for cases group (table 4) and 1.7+_0.41(ranging from 1.0 to 2.90) for controls group (table8), RI was 0.69+/- 0.41 (ranging from 0.40 to 1.08) for cases group and 0.81+/-0.09 (ranging 0.56-1.20) for controls group and S/D ratio was 3.2+/-0.88 (ranging from 1.40 to 5.50) for cases group and 3.7+/-0.83 (ranging 2.20- 5.0) for controls group .

Riskin-Mashiah S *et al.* [16] reported that women destined to develop pre-eclampsia had lower middle cerebral artery (MCA) resistance index (RI) and pulsatility index (PI) weeks before the development of pre-eclampsia. And B. Mallikarjunappa *et al*. [1] said that decreased PI in middle cerebral artery indicating presence of decreased impedance to cerebral circulation, such fetuses is at high risk of poor perinatal outcome.

Out of 100 cases group 55% present with mild PE (table5), with the mean of indices: 3.4+/-0.95 S/D ratio, 0.72+/-0.12 RI and 1.5+/-0.47 PI (table7), versus 45% present with sever PE with the mean of indices: 3.0+/- S/D ratio, 0.65+/-0.14 RI and 1.6+/-0.52 for PI. Padmini C. P.*et al*. [13] found that Out of 80 cases, 41cases (52%) were mild preeclampsia and 39 cases (48%) were severe preeclampsia.

From 100 cases group and 121 controls group 88cases and 80 cases respectively were followed up, 52.3% from cases group developed IUGR (Ultrasound estimation of fetal weight (using fetal biometry) below

10th percentile for that gestational age was labeled as IUGR) (table6), with the means: 3.1+/-0.72 for S/D ratio, 0.66+/-0.13 for RI and 1.6+/-0.50 for PI (table7), versus 47.7% not developed IUGR with means: 3.4+/-0.99 for S/D ratio, 0.72+/- 0.13 for RI and 1.5+/- 0.47 for PI. Where in controls were2.5% (table11) with means 4.6+/-0.49 S/D ratio, 0.79+/-0.14 RI and 1.8+/-0.98 for PI (table12).

A number of longitudinal studies have assessed several fetal vessels with Doppler US and have reported that the cerebral circulation is of the first blood flows to become abnormal in IUGR[17,18].

Abnormal umbilical Doppler indices and abnormal cerebral-umbilical ratio are strong predictors of IUGR and of adverse perinatal outcome in preeclampsia [19].

Preterm delivery present in 33% cases group (table6), with means 3.1 +/-0.96 S/D ratio, 0.64+/-0.11 RI and 1.5+/-0.45 for PI, (table7), versus 67% did not with means 3.3+/-0.83, 0.71+/-0.14, and 1.6+/-0.51 indices respectively.

15.9% from cases group shows intrauterine fetal death (table6), with the means of indices: 2.7+/-0.80 S/D ratio, o.61+/-0.95 RI and 1.3+/-0.40 PI (table7), versus 84.1did not shows IUFD, with means 3.3+/-0.86, 0.70+/-0.14 and 1.6+/-0.50 indices respectively.

These results matching B. Mallikarjunappa *et al*.[1] results whom found among 100 PE cases, preterm deliveries 32%, perinatal death 16%, low birth weight 38%, fetal distress 14%.

67% delivered by cesarean section (table6), with means 3.2+/-0.86 S/D ratio, 0.69+/-0.14 RI and 1.6+/-0.51PI (table6), versus 33% shows normal delivery (table7), with means 3.3+/-0.91, 0.69+/-0.12 and 1.4+/-0.41 indices respectively for cases group. Where in controls 11.1% delivered by cesarean section (table11) with means 3.7+/-0.99 S/D ratio, 0.80+/-0.18 RI and 1.6+/-0.45PI (table12), and 82.7% shows normal delivery (table11) with means 3.7+/-0.87, 0.80+/-0.89 and 1.7+/-0.40 indices respectively (table12).

Severi *et al*. [20] concluded that SGA fetuses with abnormal fetal MCA waveforms have an increased risk of developing distress and being delivered by emergency cesarean section.

20.5% from followed up cases developed eclampsia (table6), present with means 3.3+/-0.76 S/D ratio, 0.69+/-0.17 RI and 1.5+/-0.48 PI (table7), versus 79.5% with means 3.2+/-0.90, 0.69+/-0.13 and 1.6+/-0.49 respectively for cases which didn't developed eclampsia.

CONCLUSION

Doppler study in pregnancy hypertension is a non-invasive hemodynamic study. Doppler US result, from middle cerebral arteries may be considered as good tools to determine hemodynamic repercussion caused by PE.

Abnormal waveforms are associated with the adverse perinatal outcome. In this study, Doppler of MCA in PE patients was found reduced. Therefore, Doppler investigation of the fetal cerebral circulation may play a key role in monitoring the fetal outcome, and helps to determine the optimal time for delivery.

Doppler study helps us to take time to plan and manage the patients in future deliveries

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